Lessons Learned from the Cold Weather Use of the Riverine Assault Craft

References

(a) Funding Document M6785496PO81396 of 5 Aug 96
(b) Funding Document M9545099WRR9ACW of 5 Oct 98
(c) PHONCON MARCORSYSCOM (CBG) Maj O'Hara/MCPD (Code 40914) Mr. G. Knighten of 29 Jan 99
(d) Required Operational Capability for Riverine Assault Craft of 3 Oct 90
(e) PHONCON MCB Camp Lejeune (2nd Small Craft Company) CWO3 Dubie /MCPD (Code 40914) Mr. L. VonNordheim of 23 Mar 99
(f) TM 09557A-14/1A Riverine Assault Craft System Operation and Maintenance
(g) ECP 3A MCPD Program Plan for RAC of 9 Feb 96
(h) ECP MCPD96E001 RAC Raw Water Strainer Basket Quick Fix of 12 Dec 96
(i) ECP MCPD96E004 RAC Thermostatic Switch of 20 Sep 96
(j) ECP MCPD97E001 R1 RAC Gauges/Senders of 14 Aug 97

Authority

The Marine Corps Programs Department (MCPD) of the Naval Surface Warfare Center, Crane Division was assigned as the In Service Engineering Agent (ISEA) for Marine Corps Small Crafts by the Marine Corps Systems Command (CBG) via reference (a). As the ISEA, MCPD is tasked annually to provide engineering support to CBG that includes Failure Analysis-Fault Isolation (FA-FI) Investigations with regard to Small Craft problems, reference (b). Under the FA-FI Work Unit Assignment, we were tasked to review and document any problems that the Marine Corps experienced with the initial use of the Riverine Assault Craft (RAC) in a cold weather environment, reference (c).

Purpose

This Lessons Learned report documents problems experienced by the Marine Corps during its use of the RAC in the cold weather environment. It also provides our assessment of the problems with recommended solutions. This information is to be used as a basis for:

- Preparation of the RAC for future cold weather environment operation
- Updating the RAC Technical Manual (TM) to cover the preparation and maintenance of the RAC during cold weather operations
- Developing required Engineering Change Proposals (ECP) on RAC system hardware

Background

The RAC Required Operational Capability specifies the RAC to be operational in environments between 25º and 125ºF, reference (d). As an operational test of the RAC in the cold weather environment, four RACs were deployed to Bangsund, Norway during February 1999.

Prior to shipment, Marine Corps implemented all known precautions in preparing the craft. Primary precautions were:

- ensuring each craft was operational
- draining all water from the raw water strainer baskets
- installing engine block heaters into each craft

MCPD ISEA engineers visited the site and inspected the crafts at Bangsund, Norway during the first three days of the Marine Corps deployment. The four RACs were not operated during the visit due to maintenance problems. However, all craft were made operational through Marine Corps maintenance actions per reference (e). The temperature range during operations was between 25ºF and 32ºF through the remainder of the deployment.

Discussion

The problems encountered were isolated into five areas:

- cooling system
- engine batteries
- slave cable for jump starting the RAC engines
- engine starters
- engines

Cooling System

Each craft was inspected by the Marines upon arrival at Bangsund, Norway. Even though the raw water strainer baskets were drained prior to shipment, the Marines found frozen water in the strainer baskets and in the primary cooling system pipes. The water frozen in the strainer baskets cracked the strainer basket's plexi-glass globe. Frozen water in the primary cooling lines blocked raw water flow such that the engine cooling system was not functioning. The Marine Corps mechanics were required to repair the cracked strainer basket globe and to place each RAC in the heated maintenance tent for up to two days prior to operations to thaw the frozen water in the raw water cooling lines.

MCPD conducted a limited study of the water trapped in the cooling system, see Appendix summary. The study confirmed that it is extremely difficult to remove all of the water in the engine and in the cooling line pipes. The water trapped between the strainer basket and the engine will tend to drain back into the strainer basket, the low point in the path, during shipment. Similarly, the primary cooling lines trap water in their low points that can not be drained unless the bow of the craft is raised to an angle greater than 45 degrees.

MCPD concluded that without changes to the cooling systems, the problems experienced by Marine Corps mechanics can not be avoided.

Engine Batteries

During the pre-operational check, the craft's engines failed to start because the batteries had very low charge to start the engine. As documented in the RAC TM, reference (f), RAC batteries will drain during storage. Paragraph 6-8 of the TM states, "The maximum length of time these batteries should be allowed to sit without charging is 6 months. However, to properly maintain the batteries, and ensure optimum operational life, they should be charged every month."

Shipment of the RACs from Camp Lejeune to Bangsund took approximately eight weeks. Batteries normally produce less charge in cold weather environments and the batteries did not receive the recommended monthly charge. The solution is to replace all engine batteries with new ones prior to extended shipments to cold weather environments.

Slave Cable for Jump Starting the RAC

The slave cable for jump starting the RAC is 20 feet long and designed to reach from one craft to another. However, the crafts were launched one at a time and the first RAC's batteries were low, there was no adjacent RAC to jump start with the slave cable. The RAC had to be jump started by the launch vehicle. The 20-foot slave cable required the vehicle and the RAC to be maneuvered in position that the slave cable could reach.

This problem can not be resolved with the current RAC supply list. However, it should be possible to provide an electrical coupler to connect two slave cables together to make a 40-foot long slave cable. Marine Corps Logistics Base, Albany should be tasked to research and provide coupler information to the users.

Engine Starters

One of the engine starters failed prior to use and was replaced with a new Prestolite starter. Unfortunately, the new starter provided by Prestolite has certain minor differences from the Prestolite starter that was used during the FY96 system improvement ECP, reference (g). The differences between the two starters are not documented and had lead to installation problems. This could only worsen because Marine mechanics rotate through the RAC system so quickly. The only solution is for MCPD to work with Prestolite to determine if they have a final configuration for their starter, and update the starter information in the TM.

Engines

After fixing the problems with the batteries and the starters, two engines failed to operate. The ISEA representatives left prior to determining the cause of failure for the two engines. Following incorporation of RAC cooling system and engine monitoring ECPs, references (h), (i), and (j), the engine problems caused by failures in the raw water strainer baskets, engine sensors and monitoring gauges appeared to decrease. Based upon this Norway experience and other failure information being reported by the users, the engine failure rates may again be on the rise. Collection of engine failure rate documentation and cause of failure data is necessary to isolate new RAC engine problems.

Conclusions

The Marines proved that the RAC is operational in a cold weather environment. With some additional support in the following areas, the users' and mechanics' efforts can be made easier:

1. Devise a revision to the raw water strainer basket and the primary cooling lines to permit draining of all of the entrapped water.

2. Have the Marine mechanics install new engine batteries prior to shipments over one month, especially to cold weather environments.

3. Marine Corps Logistics Base, Albany provide an electrical coupler to connect two slave cables for the RAC. If no electrical coupler is currently available in the system, unique coupler may have to be designed and added to the RAC supply list.

4. The vendor's changes to the engine starter must be documented to make replacement easier.

5. Engine failure rates and causes need to be investigated and documented to determine if new problems are occurring.

Recommendations

MCPD be tasked to design a means for draining all water from the cooling system, document vendor changes to the engine starter, and capture failure data on the engines.

Marine Corps Logistic Base Albany be tasked to determine if an electrical coupler for the slave cables exists in the system and add it to the RAC supply list.

Appendix: Raw Water Investigation

Summary

As a follow-up investigation to the conditions observed on the four Riverine Assault Crafts (RAC) sent to Norway, the raw water cooling system on RAC 004 located at Fallbrook, CA, was examined to determine where and how much raw water remained in the system following operation. The following table shows the locations examined and how much water was removed.

RAC 004 Raw Water Cooling System

Step No.	Location	Water Removed	Notes
1	Port duplex strainer (inboard)	2275 ml	
2	Port duplex strainer (outboard)	2050 ml	
3	Stbd duplex strainer (inboard)	2225 ml	
4	Stbd duplex strainer (outboard)	2175 ml	
5	Port heat exchanger	0 ml	No water drained when drain plug was removed.
6	Stbd heat exchanger	0 ml	No water drained when drain plug was removed.
7	Port aftercooler	1300 ml	
8	Stbd aftercooler	1300 ml	
9	Port strainer (inboard-selected side)	500 ml	This water drained back down into the strainer after a period of 72 hours.
10	Stbd strainer (inboard-selected side)	850 ml	This water drained back down into the strainer after a period of 72 hours.
11	Port raw water line (strainer to pump)	2200 ml	
12	Stbd raw water line (strainer to pump)	2300 ml	

Conclusions

The raw water line from the sea chest to the duplex strainers was not drained due to the absence of drain plugs and difficulty in accessing/loosening the pipe couplings.

Prior to shipping the RAC's to Norway, Marine Corps personnel performed only Steps 1-4 to drain the raw water system. It is not possible to remove all of the water merely by emptying the duplex strainer baskets. As can be seen from the above data, at least 8450 ml of water, as well as the unknown amount cited in the remarks remained, with some of the water draining back into the duplex strainers.